CHAPTER 15

On-Site Decentralized Wastewater Treatment Systems

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15.1 Preface

This chapter presents the method to determine the proper design for small flows other than those regulated by TCA 68-221-401 *et seq*. Small flows are defined as domestic wastewater flows up to 150,000 gallons per day.

15.2 General Considerations

15.2.1 Ownership

Plans for sewer systems including small domestic wastewater treatment systems will not be approved unless ownership and responsibility for operation are by a municipality, publicly owned utility, or a privately owned public utility regulated by the Tennessee Regulatory Authority (TRA). The owner is defined as the entity responsible for the operation of the system. The property being served is defined as the user.

Legal title to tanks, pumps, or other components must be vested with the owner. The objective of having title invested to the owner rather than the user is to avoid potential for cost disputes over equipment selection and repair methods. Regardless of where title is vested, the owner shall completely control all tanks, pumps, service lines and other components of the system on private property. This requirement is essential to assure operable hydraulics and overall system reliability.

The owner shall possess a recorded general easement or deed restriction to enter the private property being served, and to access the system and its components. Access must be guaranteed to operate, maintain, repair, restore service and remove sludge.

Owners shall operate and maintain facilities without interruption, sewage spills on the grounds, sewage backup into buildings, or other unhealthy conditions.

15.2.2 Planning

The applicant shall contact the Water Pollution Control and/or Ground Water Protection (depending on proposed system flow) as early as possible in the planning process. If a discharge to surface waters is proposed, the treatment works will be designated an appropriate Reliability Classification as detailed in Chapter 1 of this design criteria. Also for proposed surface water discharges, the designer shall refer to the Wastewater Discharge Checklist, Appendix 1-A. Additionally, all large capacity (serving more than 20 individuals) systems with a subsurface disposal are required to obtain an underground injection control permit from the Division of Water Supply.

15.2.3 Consideration of Alternatives

First, the engineer must examine the economic and environmental feasibility of transporting flows to a municipal wastewater treatment plant. Economic feasibility evaluations must include cost to the developer of extending sewers to the development, the installation of sewers inside the development, the installation of any lift stations required and the cost of any tap fees charged by the municipal system to connect. Then, the engineer must consider the use of subsurface disposal systems as authorized by TCA 68-221-401 *et seq*. Each of these alternatives would result in a managed sewerage system protective of the water environment and public health.

15.3 Design Basis

Small systems are more sensitive to influent problems due to a reduction in hydraulic or organic buffering capacity. Small systems are much more susceptible to flow variations due to daily, weekend or seasonal fluctuations. An accurate characterization of the waste and flow conditions must be projected for the site and must include flow, BOD_5, TSS, ammonia and, oil and grease.

15.3.1 Hydraulic Loading

For residential developments, the flows given below are generally considered appropriate for design purposes. For developments that include a preponderance of larger homes, higher flows should be considered. For non-residential flows, the engineer should use the tables given in Appendix 15-A. If the engineer determines that it is necessary to deviate from those values, then he/she must submit the basis for design flow, both average and peak. The type of collection system should be given serious consideration when determining total flow to the wastewater treatment plant. Table 15-1 are values derived from EPA's *"Onsite Wastewater Treatment Systems Manual"* (EPA/625R-00/008, February 2002) and TDEC's experience.

TABLE 15-1

Number of Residential Units	Flow Basis
0 – 10	**150** GPD per bedroom
11 – 50	**300** GPD per lot
> 50	**250** GPD per lot

15.3.2 Engineering Report

An engineering report is required for all wastewater treatment projects. Small treatment plants require different design considerations than larger plants. During the design of a small treatment facility, the design engineer shall evaluate the feasibility of various process alternatives. An engineering report must be submitted to the Department of Environment and Conservation. For land dispersal systems utilizing secondary treatment followed by drip effluent dispersal, the engineering report must be submitted to the

Division of Groundwater Protection. The engineering report must detail the method of determining the chosen treatment alternative. The reliability of the treatment alternatives must be examined with respect to the sensitivity of the receiving stream for direct discharges and ground water protection for subsurface disposal. Thus, engineering and environmental judgments shall be used to balance the economy of construction and operations with the reliability of appropriate treatment alternatives based on the sensitivity of the site.

Except for single residential units, all other on-site decentralized systems must also submit an application for a State Operations Permit (SOP) to the Division of Water Pollution Control. The SOP application must include an extra-high intensity soils map, soil boring logs and pit evaluations to determine soil type, texture and structure for all areas proposed for drip dispersal or spray irrigation.

15.3.3 Pollutant Loading

While best engineering judgments for waste characterizations are sometimes necessary, an attempt should be made to project this character from similar facilities, instead of the absolute use of flow tables. For example, excess ammonia should be considered during design of a treatment system for a rest stop, truck stop or recreational vehicle park. These types of facilities can have a significantly higher influent ammonia concentration than typical domestic systems. Table 15-2 are values associated with domestic wastewater derived from EPA's *"Onsite Wastewater Treatment Systems Manual"* (EPA/625R-00/008, February 2002).

TABLE 15-2

Influent Concentrations
Associated with Domestic Wastewater

Pollutant	Concentration mg/L
BOD_5	**240**
TSS	**270**
TKN	**60**
TP	**10**
FOG	**70**

In general, the values in Table 15-2 are associated with raw domestic wastewater and are not indicative of wastewater effluents from STEP or STEG systems. Table 15-3 shows typical influent and effluent data from twenty-four (24) onsite wastewater systems in Tennessee using a Recirculating Sand Filter (RSF) followed by disc filter and UV disinfection.

TABLE 15-3

Typical Data Associated with Recirculating Sand Filters (RSF)

PARAMETER	INFLUENT	EFFLUENT
BOD_5 (mg/L)	**193**	**BDL**
Ammonia (NH_3-N), mg/L	**44.6**	**0.8**
Nitrate (NO_3-N), mg/L	**NA**	**13.6**
TSS, mg/L	**38**	**<2**
Fecal Coliform, CFU/100 ml	**NA**	**<2**

15.4 Preliminary Treatment

Preliminary treatment involves the removal of large solids that could damage pumps and equipment in the downstream treatment process. Such treatment may include properly designed and water tight septic tanks, filters (See Appendix 15-B) or grinder pumps.

15.4.1 Septic Tank Effluent Pumped (**STEP**) and Septic Tank Effluent Gravity (**STEG**)

Septic tanks must be sized to accommodate a minimum of two and one-half (2.5) times the design daily sewage flow anticipated to flow through the tank. Additionally, septic tanks may be either compartmentalized or not, since unbaffled tanks allow the tank to be pumped from either end. All tanks regardless of size shall be water-tight as evidenced by post installation testing and structurally sound as certified by a Licensed Professional Engineer stamp on tank plans and structural analysis. Structural soundness will require reinforcing bars incorporated into the tank walls, sides, top, and bottom.

All tanks shall be equipped with rubber inlet and outlet boots installed through the tank wall and sealed to the piping with stainless steel band clamps. All tanks shall be equipped with water-tight risers over the inlet and outlet of the tank and sealed to the tank by welding to a riser ring poured into the top of tank. All risers shall extend to grade and be equipped with a water-tight lid bolted or locked to the riser.

All septic tanks, except for large, multi-user tanks (which may have to be cast in place) shall conform to ASTM standard C1227-05. Large, multi-user tanks that are cast in place must adhere to the following requirements:

a. Walls, bottom and top of reinforced-concrete tanks shall be designed across the shortest dimension using one-way analysis. Stresses in each face of monolithically-constructed tanks may be determined by analyzing the tank cross-section as a continuous fixed frame.

b. The walls and bottom slab shall be poured monolithically.

c. Reinforcing steel shall be ASTM A-615 Grade 60, fy = 60,000 psi. Details and placement shall be in accordance with American Concrete Institute (ACI) 315 and ACI 318.

d. Concrete shall be ready-mix with cement conforming to ASTM C150-05, Type II. It shall have a cement content not less than six sacks per cubic yard and maximum aggregate size of 3/4 inch. Water/cement ratio shall be kept low (0.35+/-), and concrete shall achieve a minimum compressive strength of 5000 psi in 28 days.

e. Tanks shall be protected by applying a heavy cement-base waterproof coating, on both inside and outside surfaces, in compliance with Council of American Building Officials (CABO) report # NRB-168;6181 or other appropriate standard.

f. Diesel or other petroleum-based products are not acceptable as form release agents.

g. Tanks must be equipped with access openings that are no less than 21 inches in diameter.

h. Tanks shall have a groove or riser ring, formed at time of casting that surrounds the access opening to facilitate the installation of the riser.

i. In order to demonstrate water-tightness, tanks (including all risers and lids) shall be tested prior to acceptance by filling with either air or water in accordance with ASTM standard C1227-05.

j. Tank burial depths must be within the structural ability of the tank to withstand the applied loads. For tanks buried deeper than 12 inches, a riser must be provided.

In a typical septic tank system, household sewage is pretreated in a watertight septic tank where gross solids and grease are held back. A “clear” effluent from the mid-depth of the tank is transported to a common or lateral sewer. In a septic tank effluent pump (STEP) system, the effluent is pumped from the septic tank under pressure to a small-diameter, pressurized collector sewer.

In most cases, a single phase, ½ HP effluent pump is adequate for septic tank effluent. However, if a working head over 150 feet is expected, a larger pump may be required.

The effluent pump must be located within a screened pump vault. The vault, at a minimum, must be fitted with 1/8-inch mesh polyethylene screen and a 4-inch diameter PVC (or equivalent) flow inducer for a high head pump.

The pump chamber must also include float switches that turn the pump on and off and activate high and low level alarms.

Effluent may also flow by gravity, where terrain allows, to small-diameter gravity collector lines. Gravity system tanks shall be equipped with an effluent filter that at a minimum consists of a 1/8-inch mesh polyethylene screen housed within a PVC (or equivalent) vault. The lateral from the tank to the collection line shall be laid at a uniform grade with no high points.

Tanks buried more than 12 inches, and tanks equipped with an effluent filter or pump must also be equipped with risers. Outlet risers are required for septic tank effluent pump (STEP), septic tank gravity (STEG) and duplex systems. Risers shall extend to the finished grade or above. Inlet risers shall have a minimum nominal diameter of 21 inches and outlet risers shall have a minimum nominal diameter of 24 inches when used with 12-inch or 15-inch diameter pump vaults, or 30-inches when used in a duplex application. All joints must be watertight and the riser must be constructed of such materials so as to prevent water inflow/infiltration. Any conduit that enters, exits or passes through the riser must be fitted with a flexible, elastic grommet that ensures a watertight connection.

Lids shall be furnished with each riser. The riser and lid combination shall be able to support a minimum of 2500 lb. wheel load. The lids should be tamper resistant.

15.4.2 Grinder Pumps

For systems served by grinder pumps, all raw wastewater should be collected from individual buildings/dwellings and transported to the pressure or gravity system by appropriately sized pumps. For restaurants or facilities with commercial-grade kitchen facilities, grease and oil interceptors (as described in 15.4.4) must be installed prior to the grinder pump.

All pumps shall have adequate operating curves that allow for pumping into the pressurized common line under maximum head conditions. Additionally, each pump must be equipped with properly installed and approved backflow prevention assembly. Furthermore, tanks shall be watertight and located above the seasonal groundwater table where possible. Installations shall ensure that odors are minimized.

15.4.3 Grease and Oil

Facilities with commercial-grade kitchen facilities shall be equipped with an effective grease and oil interceptor. Other potential sites of grease/oil production should be investigated by the design engineer.

One or more interceptors in series are required where grease or oil waste is produced that could hinder sewage disposal or treatment, and/or create line stoppages. Interceptors must be located so as to provide easy access for inspection, cleaning and maintenance. In commercial-grade kitchen facilities, the dishwasher(s) must not be connected to the primary grease trap and/or separator. A separate device may be required to allow for cooling of the dishwasher discharge prior to primary treatment.

As vegetable oil usage has become more common, it should be understood that oils will not solidify until approximately 70^{o} F. or less. Therefore, the minimum interceptor design shall be a baffled, three-compartment, elongated chamber to allow for cooling with a capacity of at least 1,500 gallons. The design shall be in accordance with accepted engineering practice. Tanks must also be sized in accordance with local requirements. The tank shall be buried, with manhole accesses to all compartments. Tanks shall be manufactured and furnished with access openings having a minimum diameter of twenty-one (21) inches. The tank top shall be able to support a minimum of 2500 lb. wheel load. Inlet plumbing shall be designed to penetrate 18 inches below the discharge invert elevation. In order to demonstrate water-tightness, tanks (including all risers and lids) shall be tested prior to acceptance by filling with either air or water in accordance with ASTM standard C1227-05.

15.5 Secondary Treatment Design

The following secondary systems shall be evaluated for small flow designs.

15.5.1 Fixed Media Biological Reactors

A fixed media biological reactor (FMBR) is an aerobic, fixed film process that uses sand, gravel or other media to provide secondary treatment of septic tank effluent. The FMBR consists of a recirculating tank, media bed with a special distribution system installed within a structure or excavation lined with impervious synthetic liner and a flow splitter device.

Design considerations include the media size, type and surface area, the required bed area and depth, dose volumes and dosing frequency.

All sites for fixed media reactors must be properly prepared before installation. For reactors that are installed directly on soil with a synthetic liner (as opposed to package units with rigid bottoms), the liner may lie directly on the graded soil if it is free from material that might puncture the liner. Otherwise, a layer of sand or other suitable material must be placed below the liner to protect it from puncturing.

15.5.1.1 Granular Media Reactor

The media bed should be sized by comparing the organic and hydraulic loads and then using the more restrictive of the two. Table 15-4 gives suggested design parameters for the reactor, support bedding and underdrain media. All media must be washed and screened to limit fines (< 0.074 mm) to less than 3 % by weight.

Design Parameter	Effective Size	Depth	Design Value
Reactor Media:			
Sand or other, similar granular media	1- 3 mm (Uniformity coefficient = 3 –4)	24 to 30 inches	3-5 gpd/ft^2 (hydraulic loading – forward flow) ≤ 5 lb BOD_5 /1000 ft^2/day (organic loading)
Gravel or other, similar granular media	1 cm diameter (Uniformity coefficient =??)	24 – 30 inches	10 - 15 gpd/ft^2 (hydraulic loading – forward flow) ≤ 10 lb BOD_5 /1000 ft^2/day (organic loading)*
Support Material	0.6 – 1.0 cm pea gravel	6 inches	
Underdrain Media	#57 inch stone	12-18 inches	

* 15 lbs BOD_5/1000 ft^2 equates to a wastewater strength of 360 mg/L BOD_5—this is too high a loading for pea gravel filters and will result in clogging.

A synthetic media may also be used as long as it meets the above criteria.

A minimum of 30 mil impermeable synthetic liner is required for the bottom and sides of the filter.

15.5.1.2 Other Fixed Media Reactors

These systems will be approved only on a case-by-case basis. The design engineer must provide adequate rationale that such systems are preferable to more traditional granular media reactors.

15.5.1.3 Distribution and Underdrain System

15.5.1.3.1 - Spacing

Emitter lines shall be placed on two (2) foot centers with a two (2) foot emitter spacing such that each emitter supplies a four (4) square foot area. These lines are best placed at depths of six (6) to ten (10) inches below the surface. The drip lines shall be laid level and shall run with the contour. Closer line and emitter spacing of twelve (12) inches will be required for heavy clay soils or very coarse sands where lateral movement of water is restricted. Using closer spacing must not reduce the size of the drip dispersal area.

15.5.1.3.2 – Sizing of Lines

Distribution pipes shall be no smaller than 1-inch.

Clean-out caps shall be provided on the ends of the distribution pipes.

In the underdrain system, pipes shall have a minimum inside diameter of 4 inches. As an alternative, collection vaults may also be employed.

15.5.1.4 Recirculation Tank and Pump System

Where a recirculation tank is used, the tank may serve as a wetwell for the septic tank effluent and treated, recirculated effluent to be pumped to the media bed. The minimum tank volume should be 1.5 times the design daily flow.

The tank shall be equivalent in strength and materials to the septic tank as described in 15.4.1. No internal baffles are necessary. An access manhole is necessary for replacement of submersible dosing pumps if such are used.

Two alternating recirculation pumps are required. Recirculating pump operation must be time-controlled. Float switches are required and must be wired in parallel with the timer to control the pumps during periods of either low or high wastewater flows, and as a back-up in case of timer malfunction.

A quick disconnect coupler and hanger pipe are recommended for pump removal and convenience.

15.5.1.5 Flow Splitter

The system must be equipped with a device that allows for reactor effluent to be split between the recycle stream and discharge to either the disinfection system and/or drip disposal area. It is recommended that the designer choose a device that provides flexibility in setting the recycle ratio.

15.5.1.6 Dosing Chamber

A dosing chamber must be employed, sized and equipped to provide timed-dosing of the daily wastewater flow with adequate reserve storage capacity for system malfunctions. The dosing chamber shall be equipped with an audible visual or other approved high-water alarm set to provide notification to the owner/operator of a malfunction when the design high water level is exceeded and the emergency reserve capacity is being used. A low-water cutoff device must be provided to prevent damage to the pump during low-water conditions. A programmable timer and control panel shall be employed to regulate the dosing frequency and volume, and to record wastewater flow, the number of doses and other pertinent dosing data.

Time dosing must be utilized to dose the absorption field or zones. The frequency of dosing shall be based upon the soil's hydraulic loading rate and the design flow. Fields or zones must be time dosed to ensure the total twenty-four (24) hour wastewater effluent flow is applied in a 24-hour period.

15.6 **Disinfection and Fencing**

Disinfection of effluent is required prior to drip dispersal of unfenced drip irrigation and all spray irrigation. If the entire drip dispersal area is properly fenced, disinfection of the effluent is not required.

In the design of UV disinfection units there are three basic areas that should be considered:

a. Reactor hydraulics – adequate residence time.

b. Factors affecting transmission of UV light to the microorganisms.

c. Properties of the wastewater being disinfected.

In addition, an automatic self-cleaning mechanism is recommended to ensure proper performance of the UV system.

As an alternative to disinfection, the drip field may be fenced with either a 4' chain link or woven wire fence.

15.7 Artificial Wetlands

The artificial wetland treatment system is a relatively new technology. Like other land application systems artificial wetlands are site specific, consequently, all proposals will be reviewed on a site-by-site basis.

15.7.1 Basis for Pond Design (Pre-Treatment)

1. The maximum design loading on the primary cell(s) shall be 30 lbs BOD5 per acre per day.

2. The design average flow rate shall be used to determine the volume required to provide a minimum combined storage capacity of 180 days in the stabilization ponds (pre-treatment system) and the artificial wetland areas. The minimum recommended storage capacity in the stabilization pond system shall be 150 days. The storage in the pre-treatment system shall be provided above the two (2) foot level. The maximum normal liquid level should not exceed five (5) feet in the primary cell or six (6) feet in the secondary cell.

3. The seepage rate for the primary cell(s) shall not exceed 0.041 inches per day. Seepage of up to 0.0625 inches per day may be allowed in secondary cells, considered on a case- by-case basis.

4. The minimum number of cells for the pre- treatment system shall be two when the system is designed to discharge.

5. The shape of the cells shall be such that there are no narrow, L-shaped or elongated portions. Round or rectangular ponds are most desirable. Rectangular ponds shall generally have a length not exceeding three times the width. Dikes shall be rounded at the corners to minimize accumulation of floating material.

15.7.2 Basis of Wetland Design

1. Design

   a. No discharge is recommended from the artificial wetland treatment system during the 180-day winter storage period unless it can be shown that the discharge meets NPDES permit limits.

   b. The maximum hydraulic design loading flow through rate on the artificial wetland(s) shall be 25,000 gallons per acre per day.

   c. The minimum recommended detention time for treatment in the artificial wetland system may be 7 days with 14 days being the most desirable.

   d. The recommended depth of flow in the wetland system shall be between 6 and 24 inches, with nine (9) inches as the recommended optimum depth.

   e. A rectangular configuration is recommended to enhance treatment efficiency in the system with a length to width ratio of between 5 and 10 to 1. However, irregular shorelines offer substantially better support for wildlife.

   f. Seepage rates in the artificial wetland areas will be addressed on a site-by-site basis based upon in-situ material, groundwater depth and the groundwater use. Generally, no compaction will be required on wetland pond bottoms. The berms shall be compacted to at least 90 percent of Standard Proctor Density.

   g. The bottom of the artificial wetland treatment units shall not have a slope greater than 0.2%.

   h. Due consideration shall be given to multiple wetland cells and to possible future expansion on suitable land when the original land acquisition is made for flexibility and for maximum operational capability.

2. Construction

   a. The project site should be protected from surface inflow waters. The site should also be protected to one foot above the 100 year flood elevation.

   b. In order to prevent erosion and channelization at the inlet of the wetland, a discharge header should be utilized. The header should be equipped with removable end-plugs so the line may be drained to prevent freeze-up. Uniform distribution of wastewater to prevent short-circuiting through the wetland shall be assured. It is recommended that the header outlet elevation be at or above the maximum design depth.

   c. It is recommended that pipes and flumes located in or near inlet and discharge structures will not be in a completely submerged condition to maintain the integrity of the system and reduce freeze-up problems.

   d. A suitable discharge structure from the wetland shall be utilized. The structure shall be adjustable so that the depth in the wetland may be modified as needed. It is recommended that the discharge or interconnecting structure outlet flow lines be 6 inches off the bottom to maintain the minimum depth.

e. Care should be taken to establish the vegetation as soon as possible after construction. The emergent vegetation, once established, should prevent the erosion of the berms of the system. Riprap may be required around the inlet and outlet structures of the wetland. A cover crop may be planted on the interior slopes to prevent erosion prior to the establishment of the emergent vegetation. Consideration may be given to the use of excelsior blanket over seeding.

f. The exterior and interior slopes of the wetland berms surrounding the wetland basins shall not be steeper than 3H:1V.

g. The top width of the berms shall be a minimum of eight feet.

h. Following the final grade, the substrate should consist of a minimum of one foot of clean inorganic/organic material of which 80-90% will pass a number 10 sieve.

i. The dike elevation should be a minimum of two feet above the high water level in the wetland.

j. If groundwater contamination is a potential problem, the bottom of the wetland may be sealed with a suitable material. However, generally no liner will be necessary in the artificial wetland.

k. Aluminum, concrete, or PVC pipe or other material generally accepted for sewers shall be specified for the piping requirements in the wetland. Provisions may be required to prevent the settling of the piping structures under load. It is recommended where structures are partially or completely submerged in ice conditions that a flexible piece of pipe be installed to allow for some movement of structure.

l. The effluent discharge structure shall be equipped with a suitable flow monitoring device, such as a flume or V-Notch weir, to monitor flows leaving the treatment site. Staff gages for measuring depths in structures should be provided where flow monitoring is required.

m. In order to accurately monitor influent flows to the artificial wetland system, an influent measurement structure shall be included.

n. The entire wetland area shall be enclosed with a suitable fence to provide public safety, exclude livestock and to discourage trespassing.

o. Warning signs shall be provided along the fence around the treatment facility. There shall be at least one sign on each side of the facility, with a minimum spacing of 500 feet.

p. Removable screens should be provided on pipe ends to prevent entrance of trash and wildlife.

3. Vegetation Establishment

a. Specifications for the seeding of the artificial wetland shall as a minimum include:

    1. Plant species and propagule type

    2. Plant distribution (vegetative zonation)

    3. Planting (including time restraints)

    4. Fertilization

    5. Water level control and site maintenance.

b. Topsoiling the graded wetland area is generally not required. Substrate properties generally do not limit the establishment of a wetland.

c. Only indigenous plant species shall be used, preferably collected within a 100 mile radius. Preferred species include, but are not limited to:

    1. Typha Latifolia - Common cattail,

    2. Typha Angustifolia - Narrow leaf cattail,

    3. Scirpus spp. - Bullrush, and/or

    4. Phragmites communis - Reed.

d. Seeding should generally be accomplished in the spring. Also, at least one fertilization should be required, preferably shortly after seed germination or at one month. The recommended fertilizer is the standard 10- 10-10 or 20-10-10 mixture at a rate of 600 lbs/ac or 300 lbs/ac, respectively. Where wastewater stabilization ponds exist, fertlilization may not be necessary, as the nutrients in wastewater may suffice.

e. For seeding, the following is recommended:

The seed should be broadcast uniformly over the substrate at a rate of 10 viable seeds per square foot. The seeds should be cultivated to subsurface depths of 0 to 1 inch followed by lightly packing, rolling or dragging the tilled surface. Flood the site with 1-2 inches of water until the seeds germinate and become several inches tall. At this time, the area should be fertilized.

f. For transplanting (the recommended method of vegetation establishment) the propagule should be transplanted, as a minimum, on a two foot grid. The number of transplants required may be calculated from Equation 15-1:

$$N = (L/D + 1) \times (W/D + 1) \quad \textbf{(Equation 15-1)}$$

where:

N = Number of transplants

D= Distance between transplants

L = Length of site (ft.)

W = Width of site (ft.)

Transplanting on a two foot grid should provide a uniform vegetative cover in one growing season. Transplants should be kept moist, but not flooded to submerged conditions. The transplants should also be fertilized, preferably with controlled release fertilizer such as Osmocote 18-5-11 for fall and winter planting, Osmocote 18-6-12 for spring planting, and Osmocote 19-6-12 for summer planting. Refer to suppliers instructions when transplanting.

4. Wildlife Enhancement (optional)

   a. Some method of detritus removal should be considered to prevent aging of the wetland. Harvesting or burning are two options available.

   b. To provide the greatest potential for wildlife enhancement, 25 to 35% of the artificial wetland surface should be open water with a depth no greater than five feet. However, care should be taken to prevent a large open water area, which could influence treatment efficiency. Several small pools are most desirable. Of the 25 to 35% open water area, approximately 10% should be reserved for the construction of erosion protection bars.

      The emergent vegetation of the artificial wetland system should comprise 65 to 75% of the available surface area with a water depth of less than two feet deep.

   c. In order to prevent mosquito-production problems, wetland systems should be designed so that the occurrence of hydraulically static areas is minimized. The majority of the natural predators of mosquito larvae are strictly aerobic, and as such, anaerobic conditions in wetlands should be avoided.

15.8 **Lagoons** (***Note: This chapter does not replace Chapter 9***)

- The maximum allowable seepage is 0.0625 inches per day.
- A lagoon must be artificially lined with clay, bentonite, plastic, rubber, concrete, or other materials to prevent groundwater pollution..
- Lagoons can be round, square, or rectangular with rounded corners. Their length should not exceed three times their width, and their banks should have outside slopes of about three units horizontal to one unit vertical.
- A lagoon must be surrounded by a 4-foot high fence with a locking gate and sign.
- There must be a 2 x 2 ft concrete pad in the center of the lagoon directly below the opening of the outlet pipe to protect the integrity of the liner.

There must be a minimum of 2 feet between the bottom of the lagoon and groundwater. The liquid depth of a lagoon should be maintained between 2 to 5 feet.

There must be a depth marker near the center of the lagoon.

A minimum of 1 foot of freeboard should be maintained.

15.9 **Package Activated Sludge Plants**

For any activated sludge or fixed film process, the criteria presented in Chapters 4, 5, 6, 7, 8, 10, 11, and 12 of these design criteria must be utilized for each unit process.

The design must include aerobic digestion or sludge holding for sludge wasting. A sludge wasting schedule should be included in the engineering report to better define operator time requirements. The disposal site or landfill must be given. Where tertiary filters are employed, the use of an equalization tank is mandatory. Also, based on the Reliability Classification as determined by the appropriate WPC field office, multiple units and standby power (or a generator) may be required. These costs must be included in the cost effective/reliability analysis.

APPENDIX 15-A

Table 3-4. Typical wastewater flow rates from commercial sources[a,b]

Facility	Unit	Flow, gallons/unit/day Range	Flow, gallons/unit/day Typical	Flow, liters/unit/day Range	Flow, liters/unit/day Typical
Airport	Passenger	2–4	3	8–15	11
Apartment house	Person	40–80	50	150–300	190
Automobile service station[c]	Vehicle served	8–15	12	30–57	45
	Employee	9–15	13	34–57	49
Bar	Customer	1–5	3	4–19	11
	Employee	10–16	13	38–61	49
Boarding house	Person	25–60	40	95–230	150
Department store	Toilet room	400–600	500	1,500–2,300	1,900
	Employee	8–15	10	30–57	38
Hotel	Guest	40–60	50	150–230	190
	Employee	8–13	10	30–49	38
Industrial building (sanitary waste only)	Employee	7–16	13	26–61	49
Laundry (self-service)	Machine	450–650	550	1,700–2,500	2,100
	Wash	45–55	50	170–210	190
Office	Employee	7–16	13	26–61	49
Public lavatory	User	3–6	5	11–23	19
Restaurant (with toilet)	Meal	2–4	3	8–15	11
Conventional	Customer	8–10	9	30–38	34
Short order	Customer	3–8	6	11–30	23
Bar/cocktail lounge	Customer	2–4	3	8–15	11
Shopping center	Employee	7–13	10	26–49	38
	Parking space	1–3	2	4–11	8
Theater	Seat	2–4	3	8–15	11

[a] Some systems serving more than 20 people might be regulated under USEPA's Class V Underground Injection Control (UIC) Program. See http://www.epa.gov/safewater/uic.html for more information.
[b] These data incorporate the effect of fixtures complying with the U.S. Energy Policy Act (EPACT) of 1994.
[c] Disposal of automotive wastes via subsurface wastewater infiltration systems is banned by Class V UIC regulations to protect ground water. See http://www.epa.gov/safewater/uic.html for more information.

Source: Crites and Tchobanoglous, 1998.

Table 3-5. Typical wastewater flow rates from institutional sources[a]

Facility	Unit	Flow, gallons/unit/day Range	Flow, gallons/unit/day Typical	Flow, liters/unit/day Range	Flow, liters/unit/day Typical
Assembly hall	Seat	2–4	3	8–15	11
Hospital, medical	Bed	125–240	165	470–910	630
	Employee	5–15	10	19–57	38
Hospital, mental	Bed	75–140	100	280–530	380
	Employee	5–15	10	19–57	38
Prison	Inmate	80–150	120	300–570	450
	Employee	5–15	10	19–57	38
Rest home	Resident	50–120	90	190–450	340
	Employee	5–15	10	19–57	38
School, day-only:					
With cafeteria, gym, showers	Student	15–30	25	57–110	95
With cafeteria only	Student	10–20	15	38–76	57
Without cafeteria, gym, or showers	Student	5–17	11	19–64	42
School, boarding	Student	50–100	75	190–380	280

[a] Systems serving more than 20 people might be regulated under USEPA's Class V UIC Program. See http://www.epa.gov/safewater/uic.html for more information.

Source: Crites and Tchobanoglous, 1998.

Table 3-6. Typical wastewater flow rates from recreational facilities[a]

Facility	Unit	Flow, gallons/unit/day Range	Flow, gallons/unit/day Typical	Flow, liters/unit/day Range	Flow, liters/unit/day Typical
Apartment, resort	Person	50–70	60	190–260	230
Bowling alley	Alley	150–250	200	570–950	760
Cabin, resort	Person	8–50	40	30–190	150
Cafeteria	Customer	1–3	2	4–11	8
	Employee	8–12	10	30–45	38
Camps:					
Pioneer type	Person	15–30	25	57–110	95
Children's, with central toilet/bath	Person	35–50	45	130–190	170
Day, with meals	Person	10–20	15	38–76	57
Day, without meals	Person	10–15	13	38–57	49
Luxury, private bath	Person	75–100	90	280–380	340
Trailer camp	Trailer	75–150	125	280–570	470
Campground-developed	Person	20–40	30	76–150	110
Cocktail lounge	Seat	12–25	20	45–95	76
Coffee Shop	Customer	4–8	6	15–30	23
	Employee	8–12	10	30–45	38
Country club	Guests onsite	60–130	100	230–490	380
	Employee	10–15	13	38–57	49
Dining hall	Meal served	4–10	7	15–38	26
Dormitory/bunkhouse	Person	20–50	40	76–190	150
Fairground	Visitor	1–2	2	4–8	8
Hotel, resort	Person	40–60	50	150–230	190
Picnic park, flush toilets	Visitor	5–10	8	19–38	30
Store, resort	Customer	1–4	3	4–15	11
	Employee	8–12	10	30–45	38
Swimming pool	Customer	5–12	10	19–45	38
	Employee	8–12	10	30–45	38
Theater	Seat	2–4	3	8–15	11
Visitor center	Visitor	4–8	5	15–30	19

[a]Some systems serving more than 20 people might be regulated under USEPA's Class V UIC Program.

Source: Crites and Tchobanoglous, 1998.

APPENDIX 15-B

1. STEG - GRAVITY ASSEMBLIES

a. EFFLUENT FILTER Gravity system tanks for single-family dwellings shall be equipped with the ORENCO SYSTEM Model F-1248125 Effluent Filter, or equivalent, installed in conformance with the standard plans. (Note: Commercial and multiple-user tanks require larger Effluent Filters, the sizes of which must be individually determined and spelled out in the specifications.) The Effluent Filter shall consist of a 12-inch diameter, 48-inch deep PVC vault with eight (8) 1-1/4-inch diameter holes evenly spaced around the perimeter, 16-inches up from the bottom, and with a fiberglass base. Housed inside the PVC vault shall be a 1/8-inch mesh polyethylene screen. The 1-1/4-inch diameter vertical intake pipe within the screened vault shall have an overflow protection screen on the top and a one 1/2-inch diameter hole near the base for flow modulation. The Effluent Filter shall also be equipped with 5-1/2 feet of 1-1/4-inch flexible PVC flex hose with a plastic quick-disconnect fitting on the vault end. (For sites with riser greater than 24 inches in height, hose length shall be increased by one foot for each additional foot of riser. Also furnished shall be PVC flex hose bushed to fit a 4-inch sanitary tee, air relief vent and fittings as shown on the plans.) The Effluent Filter shall be suspended from the top of the septic tank by supports which shall be provided by ORENCO SYSTEMS, INC., or equivalent. The lateral from the tank to the collection line shall be laid to a uniform grade with no high points.

2. STEP PUMPING ASSEMBLIES for Single-Family Dwellings

MATERIALS All pumping systems shall be ORENCO SYSTEMS High-Head Pumping Assemblies or equivalent composed of:

a. Risers & Lids.

b. Screened Pump Vault. Model SV1260Fi or SV1548Fi, PVC vault, or equal, fitted with 1/8-inch mesh polyethylene screen and a 4-inch diameter PVC flow inducer for a high head pump.

c. Discharge Hose and Valve Assembly. Model HV100BX, or equal, 1-inch diameter, 150 psi PVC ball valve, PVC flex hose with working pressure rating of 100 psi, Schedule 40 PVC pipe, and a 12-inch length of PVC flex hose with fittings to be installed outside the riser. Six-gpm flow controller optional.

d. Mercury Switch Float Assembly. Model MF-ABR, or equivalent, with three mercury switch floats mounted on a fixed PVC stem attached to the pump vault. The high- and low-level alarms and on-off functions shall be present as shown on the drawing. Each mercury switch float shall be secured with a nylon strain relief bushing. The "A" & "R" floats shall be

UL- or CSA- listed and shall be rated for 4.5 A@ 120 V. The "B" float shall be UL- or CSA- listed and shall be rated for 13 A@ 120 V.

e. High-Head Effluent Pump. Model 8 OS105HH, or equal, 1/2 Hp, 115V, single phase, 60 Hz, 2-wire motor, 8-foot long extra heavy duty (SO) electrical cord with the ground to motor plug. Pump shall be UL listed as an effluent pump. (Note: if working heads over 150 feet are expected, a Model 8OS107HH or larger equivalent pump may be specified.)

f. Electrical Splice Box. UL approved for wet locations, equipped with four (4) electrical cord grips and a 3/4-inch outlet fitting. Also included shall be UL-listed butt splice connectors. (Note: Specifications for the EY conduit seal shall be covered in another section.)

g. Controls & Alarms. Model A-1RO, or equivalent control panel with the following:

(i). Redundant-Off Relay: 115V., automatic, single pole.

(ii). Audible Alarm: Panel mount with a minimum of 80 dB sound pressure at 24 inches. Continuous sound.

(iii). Visual Alarm: NEMA 4-rated, 7/8-inch diameter, oiltight, with push-to-silence feature.

(iv). Audio-Alarm Reset Relay: 115 V, automatic, with DIN rail mount socket base

(v) Toggle Switch: 15 amp motor rated, single -pole, double-throw with three positions: manual (MAN), (OFF) and automatic (AUTO).

(vi) Fuse Disconnect: DIN rail mount socket base with 2 amp SLO BLOW fuse.

(vii) Current-Limiting Circuit Breaker: Rated for 20 amps, OFF/ON switch, DIN rail mounting with thermal magnetic tripping characteristics.

(viii) Enclosure: NEMA 4X-rated, fiberglass with stainless steel or non-metallic hinges, stainless steel screws and padlockable latch. 8-inches high X 6-inches wide X 5-1/8 inches deep.

(ix) Alarm Circuit: Wired separately from the pump circuit so that, if the pump's internal overload switch or current-limiting circuit breaker is tripped, the alarm system remains functional.

2. INSTALLATION All pumping systems shall be installed in accordance with the manufacture's recommendations and the standard plans.

3. LOCATION The pump control panel shall be mounted on the side of the house nearest the tank and pump. NEC requires that the control panel be located within 50 feet of and within sight of the pump.

E. STEP PUMPING ASSEMBLIES for Commercial or Multiple-User Tanks

Note: Standard dimensions and materials for specifying pumping assemblies for other than single-family dwellings can be found in OSI's price list and in OSI's design-aid chart entitled "Commercial & Multiple User Effluent Pumping Systems". Engineers at OSI are available to provide assistance. The sizing of the larger capacity tanks should be based on a 4 to 1 length to width ratio.

APPENDIX 15-C

Recirculation Tank/Pump System Example Calculation

Given: 20,000 gpd (14 gpm) system a desired 4:1 recycle rate and numerous small doses.

1. Pumping volume = (1440 min/day / (On + Off time)) x On time x # of pumps x Pump Capacity
2. 80,000 gpd = (1440 min/day / (On Off Time) x On Time x 4 x 45 gpm
3. 80,000 gpd/(1440 min/day x 4 x 45 gpm) = On time/(On + Off time)
4. On time/(On + Off time) = 0.31
5. On time = 0.31 On + 0.31 Off
6. 0.69 On = 0.31 Off
7. Off = 2.22 On
8. Choose 2 minutes On: Off = 4.44 minutes
9. Total dosing cycle = 6.44 minutes.
10. Adjust dose cycle if calculated pumping volume is less than minimum recommended for selected recycle rate
11. Note: This is an iterative process. The quickest solution is to pick a cycle time, divide it into 1440 min/day, multiply by the On time, multiply by the number of pumps, and multiply by the pump capacity. Compare this number to the desired total pumping volume including recycle. If too little increase On time. If too much decrease On time. .